D09

MAPPING SO_2 FROST AND SULFUR ON IO'S SURFACE

Laboratory experiments on SO_2 frost and other sulfur compounds were combined with observational data from the International Ultraviolet Explorer (IUE) spacecraft to estimate the distribution of SO_2 and sulfur on the surface of Io, which is in synchronous rotation about Jupiter. The results have been indirectly confirmed by the Voyager spacecraft.

JPL research has established that frozen SO_2 is more abundant on Io's leading side at longitudes between 72 and 137 degrees, and that sulfur allotropes are most abundant on the trailing side at longitudes from 250 to 323 deg.

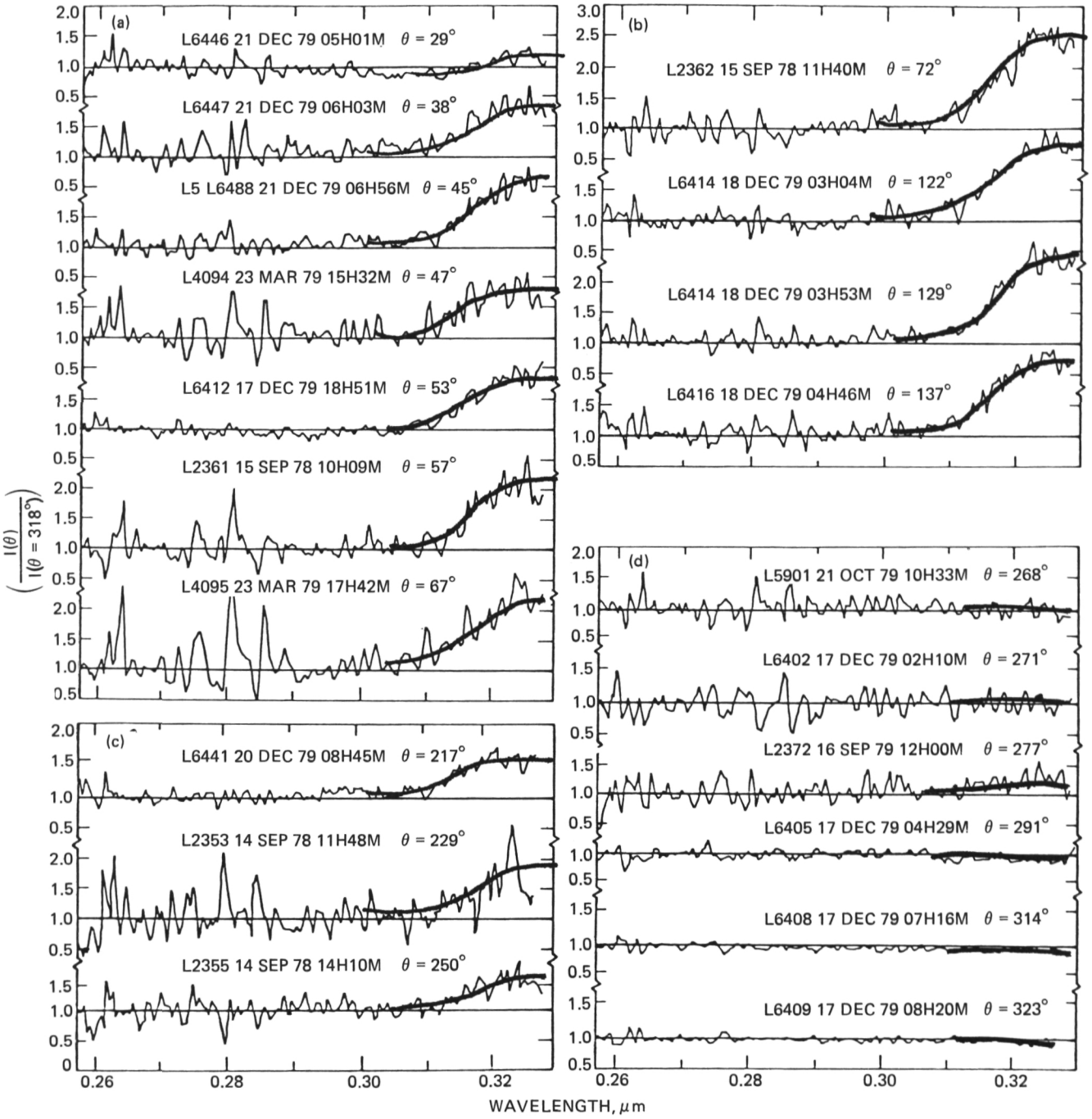
Last year JPL experimenters identified frozen SO_2 as a significant component of Io's surface material by comparing laboratory infrared reflectance spectra of SO_2 frost with Earth-based telescopic spectra of Io. This year the observational and laboratory work was extended into the ultraviolet to learn more about Io's surface composition. A laboratory spectrum of SO_2 frost was measured in the ultraviolet and visible spectral range. When compared with Earth-based spectra of Io, the new laboratory data served to strengthen the case for the existence of an SO_2 solid phase on the satellite, and at the time to set an upper limit on the fraction of Io's disk that is covered by SO_2 frost at less than 20 percent.

Analysis of 20 IUE ultraviolet spectra of Io, gathered by JPL observers using IUE, showed that the strength of the distinct ultraviolet absorption band they found near 0.31 micrometer varied systematically with Io's orbital phase angle (i.e., the position of Io in its orbit about Jupiter) at the time of each observation. This discovery, combined with Io's synchronous rotation about Jupiter, led to the conclusion that the abundance of frozen SO_2 on Io varies with longitude.

The variation in frozen SO_2 abundance is inversely related to another spectral feature on Io at 0.4-0.5 μm that had been attributed by previous observers to the presence of allotropic forms of sulfur. Thus, it was concluded that at Io longitudes where frozen SO_2 is most abundant, the sulfur allotropes are least abundant and vice versa.

While the Voyager imaging cameras were not designed to respond to the 0.31-μm feature in frozen SO_2, the spacecraft saw the white areas on Io. The whitest areas correspond to those with the heaviest concentrations of SO_2, according to IUE observations.

Figure (opposite page): Io's sulfur dioxide frost is shown in the broad band marked on these data charts of the IUE spacecraft measurements of the variation of Io's ultraviolet spectral reflectance. All spectra have been divided by the spectrum at an orbital phase angle of theta equals 318 degrees. Changes in the spectral intensity between 0.30 and 0.33 μm are interpreted to be due to variations in the fractional cover of SO_2 frost on Io's apparent disk as observed by IUE from Earth orbit.


(a)
L6446 21 DEC 79 05H01M θ = 29°
L6447 21 DEC 79 06H03M θ = 38°
L5 L6488 21 DEC 79 06H56M θ = 45°
L4094 23 MAR 79 15H32M θ = 47°
L6412 17 DEC 79 18H51M θ = 53°
L2361 15 SEP 78 10H09M θ = 57°
L4095 23 MAR 79 17H42M θ = 67°
(b)
L2362 15 SEP 78 11H40M θ = 72°
L6414 18 DEC 79 03H04M θ = 122°
L6414 18 DEC 79 03H53M θ = 129°
L6416 18 DEC 79 04H46M θ = 137°
(c)
L6441 20 DEC 79 08H45M θ = 217°
L2353 14 SEP 78 11H48M θ = 229°
L2355 14 SEP 78 14H10M θ = 250°
(d)
L5901 21 OCT 79 10H33M θ = 268°
L6402 17 DEC 79 02H10M θ = 271°
L2372 16 SEP 79 12H00M θ = 277°
L6405 17 DEC 79 04H29M θ = 291°
L6408 17 DEC 79 07H16M θ = 314°
L6409 17 DEC 79 08H20M θ = 323°
$\frac{I(\theta)}{I(\theta = 318°)}$
0.26
0.28
0.30
0.32
WAVELENGTH, μm